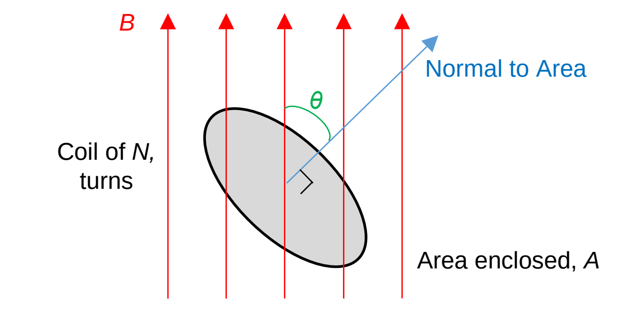
Electromagnetic Induction

Magnetic Flux, ϕ – the product of the mangetic flux density *normal* to the surface and the area of that surface.
Magnetic Flux Linkage, Φ – the product of the magnetic flux passing through the coil and the number of turns on the coil.
Weber – the SI unit for magnetic flux. One weber (1 Wb) is the flux that cuts through a surface with area of one square metre placed in a magnetic field of flux density one tesla with the surface perpendicular to the magnetic flux.

	Magnetic flux $\phi = BA\cos\theta$ Magnetic flux linkage $\Phi = NBA\cos\theta$ Both ϕ and Φ are scalar quantities

Faraday's law – the magnitude of the electromotive force induced ion a conductor is proportional to the rate of change of magnetic flux linkage of the conductor.

$$|E| = \frac{d\Phi}{dt} = \frac{d(NBA\cos\theta)}{dt}$$

Depending on what is 'changing':

$$|E| = (NA\cos\theta)\frac{dB}{dt}$$

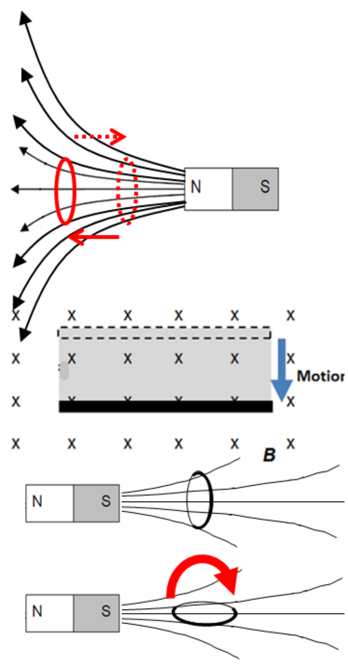
Flux density through conductor is **changing**

$$|E| = (NB\cos\theta)\frac{dA}{dt}$$

Area swept normal to the field is **changing**

$$|E| = NBA\frac{d}{dt}(\cos\theta)$$

Angle between surface normal & field is **changing**

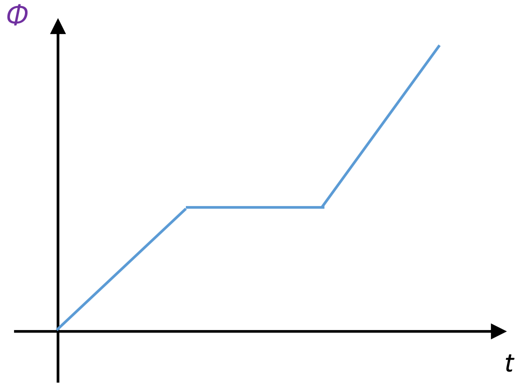


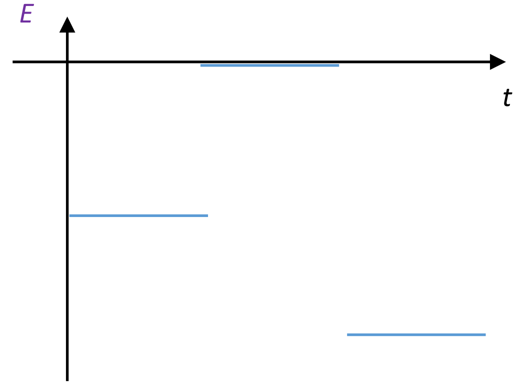
Lenz's Law – the direction of the induced electromotive force (e.m.f.) is such that it produces effects to oppose the change causing it, $E = -\frac{d\Phi}{dt}$

Factors affecting magnitude of induced e.m.f. → *N, B, A, θ* and how fast the change takes place.

1. When there is no change in any of the factors, no induced e.m.f. regardless the values for *N, B, A* and *θ*

Translating *Φ* – *t* graph to *E* – *t* graph and vice versa

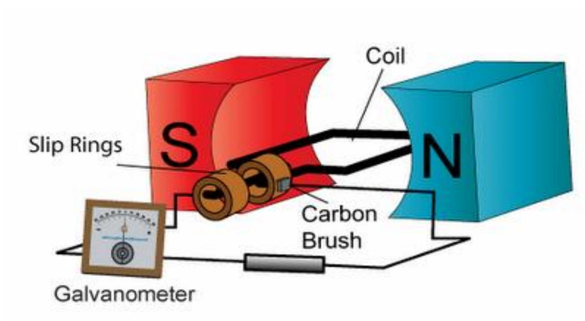




- Gradient of *Φ* – *t* graph gives the value of *E*
- *E* is negative in general to reflect Lenz's law
- Since *N*, *B* and *A* are proportional to *Φ*, graph profile of *N*, *B* and *A* are the same as *Φ*

Sinusoidal Function of magnetic Flux Linkage

In an AC generator where a coil is rotating in a uniform magnetic field,

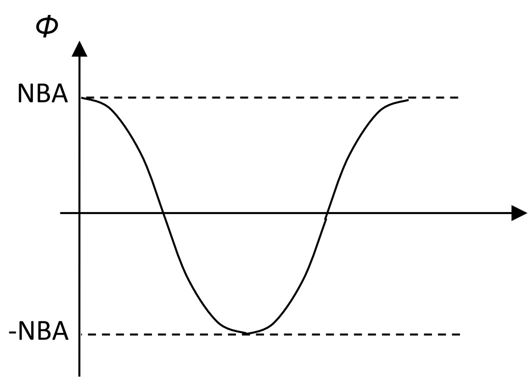


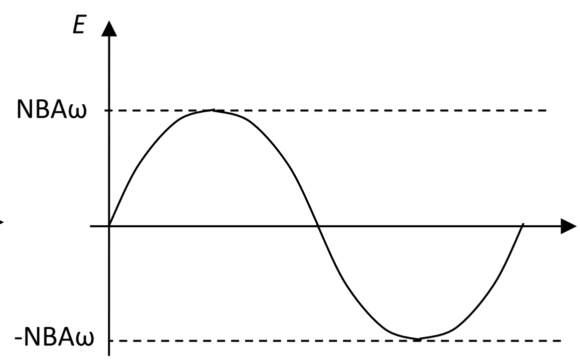
When coil is rotated at a uniform angular velocity, ω, then,

$$\theta = \omega t$$

$$\Phi = NBA\cos(\omega t)$$

$$E = -\frac{d\Phi}{dt} = NBA\omega\sin(\omega t)$$





Explain Electromagnetic Induction

<u>Whether there is an induced e.m.f.? And which direction is the induced current?</u>

1. Identify the relevant changes
    a. When the bar magnet approaches the coil, the magnetic flux density experienced by the coil increases
2. Link to a change in magnetic flux linkage
    a. Hence, the magnetic flux linkage of the coil increases
3. Apply Faraday's Law
    a. By Faraday's law, the rate of change of magnetic flux linkage of the coil induced an e.m.f. in the coil
    b. If there is a closed circuit, an induced current flows in the circuit
4. Apply Lenz's Law
    a. By Lenz's law, since there is an increase in magnetic flux density towards the right, the induced current will create an induced magnetic flux density towards the left.
5. Answer the question and state the direction of induced current